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CHEMISTRY.—*A reaction between soils and metallic iron.*[1]

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INTRODUCTION

In connection with the Bureau of Standards Soil-Corrosion Studies, which have been in progress for several years, the problem of determining the causes of corrosion of iron or steel in different soils is of scientific as well as of practical interest. A solution of this problem would enable one to distinguish soils, which are corrosive to ferrous materials, from less corrosive soils, and therefore would be of practical assistance to one charged with the responsibility of protecting pipe lines from corrosion. It was hoped that a procedure might be developed whereby the relative corrosiveness of soils could be determined in the laboratory within a few days—a determination which now requires a period of years. While this hope has not been completely realized, some information regarding a reaction between soils and metallic iron has been obtained, which may be of interest to those who are more concerned with the properties of soils than with the corrosion problem. The scope of this paper is therefore limited to a presentation of some data on this reaction.

In order to obtain a test by which results could be obtained within a short period of time, it was necessary either to devise a very sensitive method of measuring the rate of corroding action or to choose conditions which would perceptibly increase this rate. To a certain extent, both of these objects were accomplished by measuring the volume of hydrogen gas evolved from a wet mixture of soil and pulverized metallic iron.

[1] Publication approved by the Director of the U. S. Bureau of Standards, Department of Commerce. Received August 5, 1929.

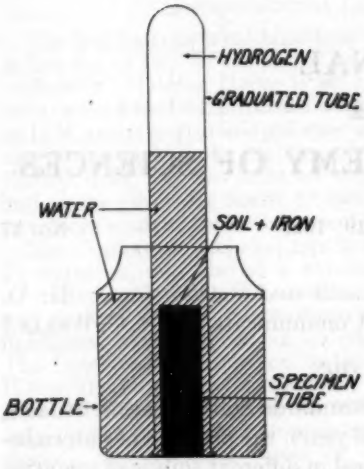


Fig. 1.—Arrangement of apparatus for collecting hydrogen gas evolved from a mixture of soil and pulverized iron.

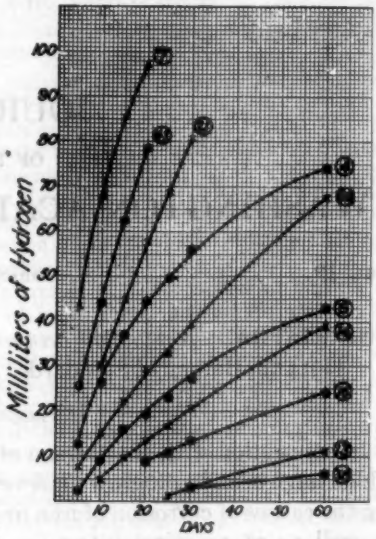


Fig. 2.—Comparative rates of hydrogen evolution obtained with 10 different soils.

Evolution of Hydrogen

Shipley[2] observed the evolution of hydrogen from the reaction of clay on cast iron, and pointed out the importance of the buffer effect of clay in maintaining the reaction over a period of time. He also suggested the probable effect of fine soil particles in reducing the overvoltage of hydrogen on the metal surface, thereby facilitating gas evolution. The writer found that the volumes of hydrogen gas evolved from different mixtures of a soil and pulverized iron or steel, under the same set of conditions, depend upon the soil and agree so closely in successive trials that the reaction may be considered as an individual characteristic of that soil.

The effects of different factors, such as fineness of metal, temperature, etc., were studied only in a qualitative way. The ferrous materials were limited to very fine steel turnings and to pulverized cast iron, both of which reacted equally well. The latter was preferred because of the ease of preparing it. This was accomplished by grind-

[2] Ind. Eng. Chem. 17: 381. 1925.

ing borings in an iron mortar and sieving out the size desired. The size used in the present tests passed through a "60-mesh" sieve. The method used for collecting and measuring the gas is illustrated in Figure 1. As convenient amounts of materials, 7.5 grams each of soil and pulverized cast iron were thoroughly mixed and poured into distilled water contained in a specimen tube. The latter was then placed in a short bottle standing in a tall beaker full of water. The graduated test tube, full of water, was then inverted over the sample. By this procedure, the mixture quickly became uniformly wet, and no perceptible amount of air was trapped. In this series of tests the time of the experiments was limited by the size (about 100 ml.) of the collecting tube.

Most of the soils listed in Table 1 were tested. In Figure 2, curves are given for ten of these soils, which represent practically the full range in activity observed. Some irregularities in the readings were obtained when bubbles of gas were trapped in the wet soil, but these were insignificant. The rate of evolution for each soil was sufficiently steady throughout the course of the test so that a comparison of rates could be made at the end of any convenient period of time. For example, the volume of gas after 20 days under specific conditions may be taken as a comparative measure of the ability of the soil to liberate hydrogen gas.

No attempt was made to elaborate upon the method of measuring the gas for the purpose of obtaining more accurate data. Attention was directed to the more important purpose of finding some other property of the soils which might be related to, and possibly be the cause of, their activity on iron.

The results of the tests showed that the amount of hydrogen evolved by a soil is not dependent upon its pH value alone. A low pH value does not necessarily indicate that the soil will give a high rate of evolution. If, however, the soil has a low pH value, together with enough material capable of buffering the solution at this pH value, a high rate may be expected. Thus, clays and silt loams are usually more active than sands. These observations indicate that the hydrogen evolved is dependent not only upon the concentration of hydrogen ions but also upon the available supply of hydrogen ions. Since this supply resides principally in the colloidal portion of the soil, it may be roughly estimated by determining the pH value and also the percentage content of colloidal matter.

TABLE 1. SOILS AND LOCATIONS

BUREAU OF STANDARDS SOIL-CORROSION INVESTIGATION

Soil No.	Soil Name	Locations
1	Allis silt loam	Cleveland, Ohio
2	Bell clay	Dallas, Texas
3	Cecil clay loam	Atlanta, Ga.
4	Chester loam	Jenkintown, Pa.
5	Dublin clay adobe	Oakland, Calif.
6	Everett gravelly sandy loam	Seattle, Wash.
7	Fairmount silt loam	Cincinnati, O.
8	Fargo clay loam	Fargo, N. D.
9	Genesee silt loam	Sidney, O.
10	Gloucester sandy loam	Middleboro, Mass.
11	Hagerstown loam	Baltimore, Md.
12	Hanford fine sandy loam	Los Angeles, Calif.
13	Hanford very fine sandy loam	Bakersfield, Calif.
14	Hempstead silt loam	St. Paul, Minn.
15	Houston black clay	San Antonio, Texas.
16	Kalmia fine sandy loam	Mobile, Ala.
17	Keyport loam	Alexandria, Va.
18	Knox silt loam	Omaha, Nebr.
19	Lindley silt loam	Des Moines, Ia.
20	Mahoning silt loam	Cleveland, Ohio.
21	Marshall silt loam	Kansas City, Mo.
22	Memphis silt loam	Memphis, Tenn.
23	Merced silt loam	Buttonwillow, Calif.
24	Merrimac gravelly sandy loam	Norwood, Mass.
25	Miami clay loam	Milwaukee, Wis.
26	Miami silt loam	Springfield, O.
27	Miller clay	Bunkie, La.
28	Montezuma clay adobe	San Diego, Calif.
29	Muck,	New Orleans, La.
30	Muscatine silt loam	Davenport, Ia.
31	Norfolk sand	Jacksonville, Fla.
32	Ontario loam	Rochester, N. Y.
33	Peat	Milwaukee, Wis.
34	Penn silt loam	Norristown, Pa.
35	Ramona loam	Los Angeles, Calif.
36	Ruston sandy loam	Meridian, Miss.
37	St. Johns fine sand	Jacksonville, Fla.
38	Sassafras gravelly sandy loam	Camden, N. J.
39	Sassafras silt loam	Wilmington, Del.
40	Sharkey clay	New Orleans, La.
41	Summit silt loam	Kansas City, Mo.
42	Susquehanna clay	Meridian, Miss.
43	Tidal marsh	Elizabeth, N. J.
44	Wabash silt loam	Omaha, Nebr.
45	Unidentified alkali soil	Casper, Wyo.
46	Unidentified sandy loam	Denver, Colo.
47	Unidentified silt loam	Salt Lake City, Utah

Estimation of Acidity

A more direct determination of the total supply of hydrogen ions, that is, "total acidity" of the soil seemed desirable for the purpose of a direct comparison with the amount of hydrogen evolved. A titration of the acidity of soils encounters difficulties, such as the detection of the end-point, time-lag of the neutralization, and the probability of constituents, other than acid, combining with part of the titrating solution. The possibility of titration with a hydrogen electrode for ascertaining the end-point seemed to be worth consideration. Accordingly, a thinly platinized platinum wire electrode supplied with hydrogen from a tank was tried. It was measured against a tenth-normal calomel electrode. The 20-gram samples of soils were stirred vigorously in 200 ml. of 5 per cent potassium chloride solution with a motor-driven propeller and titrated with a normal solution of potassium hydroxide. The stirring was started immediately after each addition of alkali but was stopped for making the readings.

Consistent readings were obtained only in the presence of the potassium chloride. This was no doubt partly due to the increased conductivity, but other reasons were probably more important. Thus, the use of this salt involves a consideration of the "base exchange" effect, according to which the hydrogen ions attached to the soil particles are exchanged for potassium ions. This would result in the presence of hydrochloric acid with which the alkali would react more readily than with the soil material. If the base exchange process simply involves a transfer of the hydrogen ions from the soil particles to the solution, and if this transfer is complete, then the hydrochloric acid ought to be equivalent to the original acidity of the soil. Then also, titration of the soil in a potassium chloride solution should be a measure of the total acidity of the soil. Whether this is true cannot be answered here.

In order to show the consistency of the readings, several titration curves for a single soil are presented in Figure 3, for which all of the readings were plotted. In Figure 4, titration curves for several typical soils are given. The curves for soils Nos. 42, 43 and x are of the strong-acid type, such as might be expected with hydrochloric acid. Those for Nos. 33 and 37 indicate buffer material associated with the high content of organic matter in these soils. The remaining soils represented in Figure 4 require different amounts of alkali to increase their pH values by a given amount, but their curves are not of the shape usually obtained in neutralization processes.

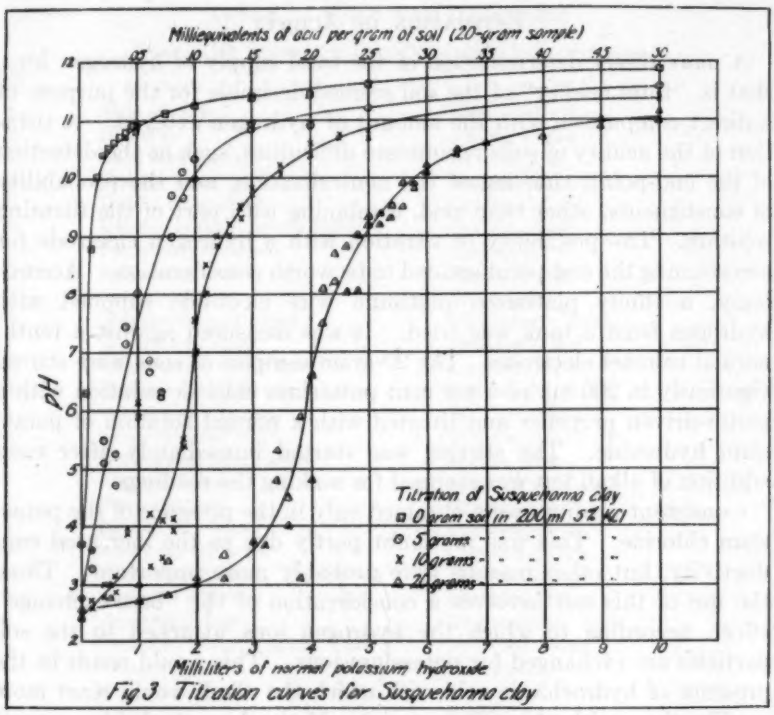

Milliequivalents of acid per gram of soil (20-gram sample)
pH
Titration of Susquehanna clay
0 gram soil in 200 ml 5% KCl
5 grams
10 grams
20 grams
Milliliters of normal potassium hydroxide

Fig 3 Titration curves for Susquehanna clay

In connection with the reaction of these soils on iron, the question arises, "What pH value should be taken as the end-point in the above-mentioned titrations?" This question may be answered if consideration is given to the change in pH which occurs when iron reacts with wet soil. Shipley and McHaffie[3] have experimentally shown that, in the absence of oxygen, iron corrodes until the pH value of the surrounding solution rises to about 9.4, corresponding to the solubility product of ferrous hydroxide. The writer has also observed that wet mixtures of soil and pulverized iron, with air excluded, practically cease to evolve gas after the pH has reached a value of 9.4 to 9.6.

[3] Can. Chem. Met. 8: 121. 1924.

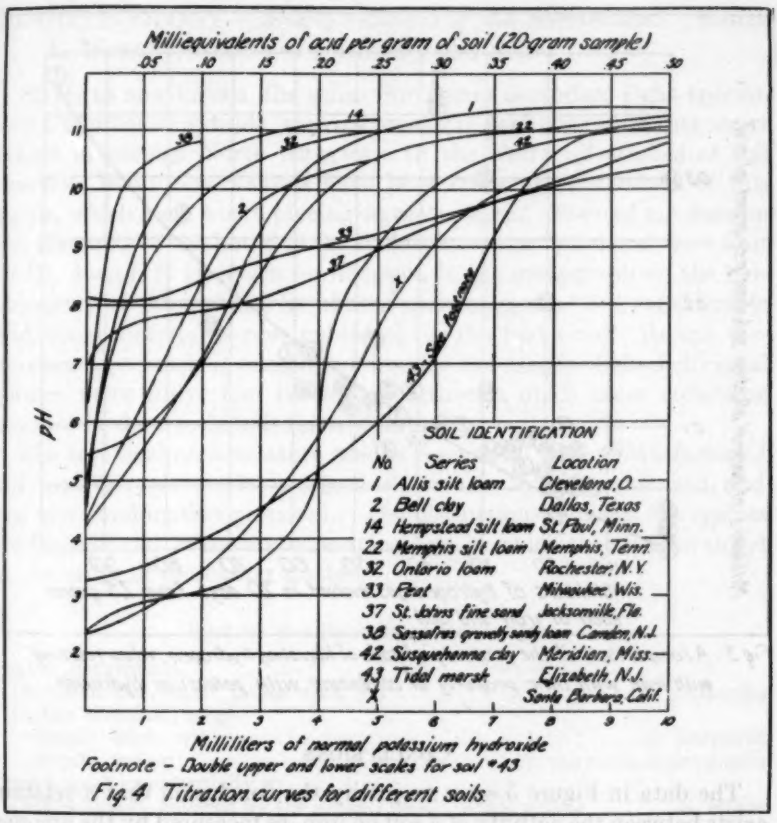

Milliequivalents of acid per gram of soil (20-gram sample)
.05 .10 .15 .20 .25 .30 .35 .40 .45 .50
pH
SOIL IDENTIFICATION
No. Series Location
1 Allis silt loam Cleveland, O.
2 Bell clay Dallas, Texas
14 Hempstead silt loam St. Paul, Minn.
22 Memphis silt loam Memphis, Tenn.
32 Ontario loam Rochester, N.Y.
33 Peat Milwaukee, Wis.
37 St. Johns fine sand Jacksonville, Fla.
38 Sassafras gravelly sandy loam Camden, N.J.
42 Susquehanna clay Meridian, Miss.
43 Tidal marsh Elizabeth, N.J.
X Santa Barbara, Calif.
Milliliters of normal potassium hydroxide
Footnote - Double upper and lower scales for soil #43

Fig. 4 Titration curves for different soils

For our present purpose, therefore, it seems reasonable to consider a pH value of 9.4 as the end-point in these titrations. If then the total acidity of the soil, as measured by the above titration, is related to the ability of the soil to liberate hydrogen, such a relation should be demonstrated by plotting the volumes of gas evolved in a given time by different soils against the total acidity of these soils. This has been done in Figure 5, where the points are denoted by the soil numbers, which refer to the soils listed in Table 1.

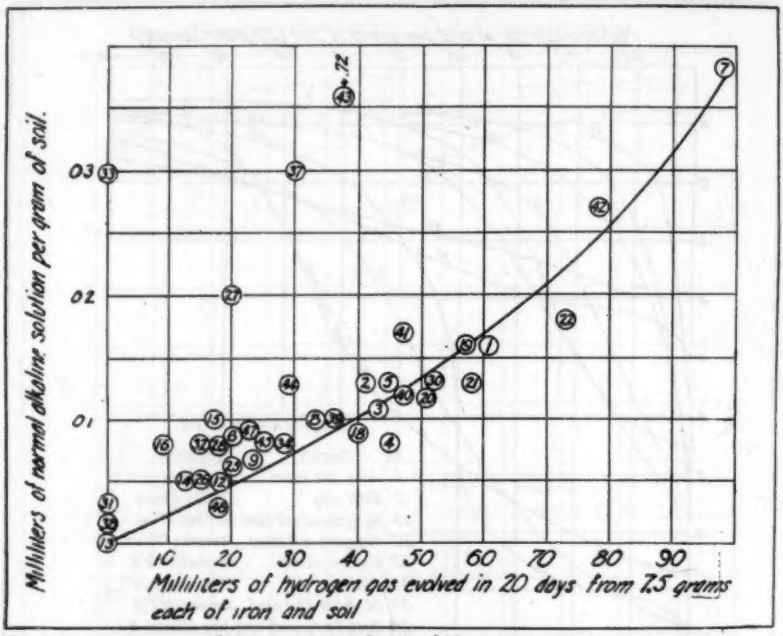


Fig 5 A comparison of the property of soils of liberating hydrogen, when reacting with iron with their property of combining with potassium hydroxide

Conclusions

The data in Figure 5 seem to justify the conclusion that a relation exists between the activity of a soil on iron, as measured by the amount of hydrogen evolved, and the acidity of the soil as measured by titration; moreover, that the acidity is probably the direct cause of its activity. The outstanding exceptions among the soils tested were few, namely Nos. 27, 33, 37 and 43, all of which were high in organic matter. These exceptions are apparently due to an abnormally high titration value or to an inhibitive effect, either of which may be associated with the organic material. It is hoped that additional studies of the reaction may throw further light upon the mechanism of corrosion and the properties of soils.

PLANT ECOLOGY.—*Acidity relations of the* Sarracenias.[1] EDGAR T. WHERRY, Bureau of Chemistry and Soils.

So far as now known, the genus *Sarracenia* comprizes eight species, and a number of hybrids, growing mostly in acid bogs and other moist places in eastern North America. In the course of studies of soil reaction, many observations have been made upon members of this genus, which seem worth placing on record here. Some of my data on the reactions of the liquid in the hollow leaves or "pitchers" were sent to Dr. Joseph S. Hepburn for inclusion in the monograph on the biochemistry of these plants by himself and associates,[2] but considerable additional material is now published for the first time. Recent discoveries have made it possible to describe the ranges of the individual species more fully than heretofore, although much more collecting needs to be done to delimit them accurately.

The technical nomenclature used is essentially that of Macfarlane,[3] although one new species is described, one new hybrid announced, and one new combination proposed. The distinctions between the species are brought out in the accompanying key, in which they are arranged in the order of increasing stature.

KEY TO THE SPECIES OF SARRACENIA

Leaves decumbent.
Orifice lateral, small; petals dark red.....*S. psittacina*
Orifice terminal, large.
Petals dark red.....*S. purpurea*
Petals yellow.....*S. purpurea heterophylla*
Leaves erect or essentially so.
Orifice closely covered by the arched hood; petals yellow.....*S. minor*
Orifice not closely covered by the hood.
Hood small, its sides not reflexed; petals dark red.....*S. rubra.*
Hood large, its sides more or less reflexed.
Reflexing of hood-sides not conspicuous.
Petals cream-colored.....*S. sledgei.*
Petals dark red.....*S. jonesii.*
Reflexing of hood-sides conspicuous.
Hood yellow-green, more or less marked with red; petals yellow *S. flava.*
Hood mottled green and white, and strongly red veined; petals red.....*S. drummondii.*

[1] Received September 10, 1929.

[2] J. S. Hepburn, E. Q. St. John, and F. M. Jones. *The Biochemistry of the American Pitcher-Plants.* Trans. Wagner Free Inst. Sci. 11: 1–95. 1927.

[3] J. M. Macfarlane. *Sarraceniaceae*, in Engler's Pflanzenreich, 4–110. 1908.

Reactions will be stated in the active acidity and alkalinity terms already explained elsewhere,[4] their significance being as follows:

	Act. acidity	pH		Act. alk.	pH
Superacid.....	8000-1000	3.1–4.0	Neutral.....	Zero	7.0
Mediacid.....	800- 100	4.1–5.0	Minimalkaline.....	0.5- 8	7.1–7.9
Subacid.....	80- 10	5.1–6.0	Subalkaline.....	10 –80	8.0–8.9
Minimacid.....	8- 0.5	6.1–6.9			

S. PSITTACINA Michaux. PARROT PITCHERPLANT

This pitcherplant occurs practically throughout southern Georgia and northern Florida, but has not been observed south of latitude 30°; westward it reaches southeastern Louisiana. Its leaves are usually partly buried in peat, and tests of the soil reaction at some ten localities have shown active acidity 200 to 500, optimum 300, so that the species is to be classed as mediacid in preference.

The pitchers of this species are usually essentially free from liquor, but by introducing a little distilled water, a solution was obtained which showed an active acidity of 300, at all five different localities where this was tried.

S. PURPUREA L. SIDESADDLE PITCHERPLANT

This most widespread species of pitcherplant ranges from northwestern Florida to southern Mississippi, north to Newfoundland and to Manitoba, Canada, growing both in sphagnum bogs and in moist mineral soil. Several hundred soil tests have been made upon it, at about fifty localities, and in the majority of cases the reaction has proved to be mediacid, an active acidity of 300 being especially frequent. At a few places on the coast of Maine superacidity was observed, the reaction reaching as high as active acidity 3,000. In the vicinity of the Great Lakes, however, very different reaction-relations are shown, as discussed in subsequent paragraphs.

A short distance northeast of Junius, Seneca County, New York, there is a series of ponds and bogs, in some of which the water is strongly alkaline, and deposits a precipitate of calcium carbonate, known as marl, on the bottom, while in others the water is acid enough to permit the growth of sphagnum moss, which produces mediacid reactions. As usual, the latter habitat supports numerous thriving plants of *Sarracenia purpurea*, but quite unexpectedly the marl areas

[4] *A new method of stating hydrogen-ion (hydrion) concentration.* Bull. Wagner Free Inst. Sci., 2: 59. 1927; and Am. J. Pharm. 99: 342. 1927.

proved to be occupied by the same species. It grows in part on hummocks of decaying vegetable matter, which, extending above the water, attain a certain degree of acidity; but many individuals are rooted directly in the marl. On testing, the humus-rich marl scraped from the plant's roots showed active alkalinity 2 to zero, the reaction being thus minimalkaline to neutral. Essentially the same results have been obtained at three different seasons, late April, before plant growth had actively started; mid-June, when the pitcherplants were in full bloom; and mid-August, when they had gone to seed.

A visit during mid-June to a point on the east shore of Lake Huron, known as Sauble Beach, in Ontario at about latitude 44° 30′, resulted in the finding of another occurrence of this plant under non-acid conditions. The lake water is subalkaline, and damp hollows between small sand dunes are essentially neutral; *Sarracenia purpurea* is abundant in these hollows.

A third locality of non-acid reaction is a bog lying north of Mineral Spring Station, Porter County, Indiana, below the southern end of Lake Michigan. The open water is distinctly alkaline, showing active alkalinity 20 when tested in midwinter, and 10 in early June. Here the *Sarracenia* grows, it is true, in hummocks of decaying vegetation, but these are thoroughly impregnated with the water and thereby prevented from becoming particularly acid, tests of the soil at the plant roots showing active alkalinity 3 to active acidity 3, or closely circumneutral reactions.

The most reasonable interpretation of these facts is as follows: Pitcherplants, having developed a means of obtaining nitrogen, phosphorus, and other essential elements through digestion of insects which drown in the pitcher liquor, are able to grow in soils in which the content of these elements, in available form, is low. Nitrogen determinations on the soils of acid and circumneutral bogs near Junius, New York, showed between 2 and 3 per cent in both types, but in neither could any nitrates or ammonia be detected, indicating this element to be relatively unavailable to plants growing there. In the presence of large amounts of available nutrients, on the other hand, these physiologically peculiar plants are unable to thrive.

It is to be inferred, then, that *Sarracenia purpurea* grows commonly in acid bogs not because it requires highly acid soil, but because in such habitats the nutrient elements are available in amounts too small to affect it unfavorably. Whenever its seeds reach circumneutral bogs where these elements are unavailable, colonies can also develop. The reason why this species is so rarely found in the latter type of

habitat is not that the neutral reaction is unfavorable, but because in circumneutral soils nutrient elements are usually available in such quantities that injury occurs.

In the course of these studies a watch was kept for the yellow-flowered and green-leaved plant listed in current botanical manuals as *S. purpurea* variety *heterophylla*, and a typical clump of it was found on a hummock at the margin of a marl pond near Junius, New York. The reaction here was subacid, active acidity 30, but the color had no connection with this, for normal red-flowered and mottled-leaved plants were abundant on adjacent hummocks of like acidity. It seems evident, from the occurrence of the yellow flowers and green leaves on rare isolated individuals in the midst of numerous normal plants, that those individuals represent not really a variety, but a mutant lacking a factor for red coloration, affecting both petals and foliage. This situation should be recognized in the nomenclature, and a new combination is accordingly proposed here:

Sarracenia purpurea mut. **heterophylla** (Eaton) Wherry, comb. nov. *S. heterophylla* Eaton. YELLOW SIDESADDLE PITCHERPLANT.

Purple pigment lacking from petals and foliage, the former correspondingly yellow, the latter green without mottling.

Several hundred reaction tests have also been made of the liquor in the pitchers of this species, and this proves to vary as much as do the soils, although no correlation can be recognized between them. The liquor-reaction has been found to range from low superacid, active acidity 1,000, to low subalkaline, active alkalinity 10. As the liquor in this species represents largely rain water, which is normally weakly acid owing to the presence of dissolved carbon dioxide and traces of salts, the possible sources of the higher acidities and of the alkalinities require consideration. In some cases, especially when the pitchers are buried nearly to the orifice in peat, splashing in of bog-water may be responsible, but even in deeply set pitchers reaction-values widely different from those of the surrounding waters have been observed. The dripping in of rain water which has trickled over the foliage of overhanging trees and shrubs may account for special values occasionally, although equally wide variations in the liquor-reaction have been noted in plants growing in the open. The alkalinity in some pitchers gave indication of being due to the decay of insects which had entered in greater abundance than usual, a distinct ammoniacal odor being perceptible; on the other hand, high acidity seemed in some instances to be connected with the presence of numer-

ous formic acid-secreting ants. That the plants themselves have no means of keeping the liquor-reaction constant is suggested by the fact that the several pitchers on a single individual often vary widely in this respect. The most extreme case observed was in a plant growing along a stream in New Mill Meadow, Mount Desert Island, Maine, where the liquor in an old leaf (containing many dead ants) had active acidity 300, while the next-adjoining younger one (with few insects of any kind) showed active alkalinity 10. The variability of reaction of pitcher-liquor in this and other species would make an interesting subject for further investigation.

SARRACENIA MINOR Walter. HOODED PITCHERPLANT

This species, sometimes known by the name *S. variolaris* Michaux, has the southermost range of all the pitcherplants, having been observed to grow as far down as Osceola County, Florida, at about latitude 28°, and to extend from there to southeasternmost North Carolina and to southern Mississippi. Its favored habitats appear to be damp meadows and low places in pine lands, where it is usually rooted in mineral soil containing more or less admixture of peat. About 25 measurements of its soil reaction have been made at five different localities, and the least acidity found was low subacid, active acidity 30, the greatest high mediacid, active acidity 500, and the usual value around active acidity 300. It is thus to be classed as a mediacid-soil plant. The reaction of the liquor in the pitchers proved to range from active acidity 100 to 1000, although 300 is the most frequent.

In the monograph cited, Macfarlane recorded the existence of hybrids of this species with *S. flava*, *S. psittacina*, and *S. purpurea*. The recognition of a new one, with *S. rubra*, may here be announced.

S. minor × rubra Wherry, hybr. nov. CANDLER PITCHERPLANT

Hybrid nature inferred from the following features: Leaves intermediate in size between those of the two presumable parents; degree of arching of hood also intermediate; translucent patches in back of hood distinct, though much less so than in *S. minor;* flowers between those of the parent species in respect to color and fragrance: petals 3 cm. long, dull red (near Ridgway's Pompeian red, 3′i) grading into yellow around the margin; odor sweet but faint. Liquor reaction found to be active acidity 300, like the two parent species.

This was discovered in a damp hollow a short distance west of Lott's Creek, about 12 kilometers (7½ miles) northeast of Metter, Candler County, Georgia, in June, 1923, and may accordingly be termed the

Candler Pitcherplant. The soil reaction there is mediacid, active acidity 300, and besides the two parents, *S. flava*, *S. psittacina*, and one or two previously known hybrids occur. The single plant found has been grown ever since by Dr. Frederick V. Coville in the U. S. Department of Agriculture greenhouses.

Sarracenia rubra Walter. Sweet Pitcherplant

The common name of this species refers to one of its most distinctive features, the delicious grape-blossom scent of its rather small maroon-red petalled flowers. It is apparently unknown in Florida, but is common in the Coastal Plain (and occasional in adjacent Piedmont) from southern Georgia nearly to Alabama and to Cumberland County, North Carolina; reports elsewhere seem to refer to the plant here separated as a distinct species under the name *Sarracenia jonesii*.

About 25 measurements of the soil reaction of this pitcherplant have been made throughout the range described, and it has been found to be invariably strongly acid, from active acidity 100 to 600, most frequently 300, indicating a mediacid preference. The pitchers rarely contain enough liquor for reaction determination, but upon adding distilled water, material dissolves and shows an active acidity of 300 in all cases tested.

Sarracenia sledgei Macfarlane. Pale Pitcherplant

The two species keyed out on the basis of having large hoods with but inconspicuously reflexed sides have been much misunderstood in the past. For many years the present one was mistaken for *S. flava*, and its distinctness was not recognized until pointed out by Professor Macfarlane in 1908. Besides the difference in hood-shape the two are dissimilar in various other respects; *S. sledgei* is notably smaller in stature and has sweet-scented flowers with creamy white petals, in contrast to the ill-scented yellow flowers of its relative. There are also technical distinctions in the capsules and seeds. Pale pitcherplant ranges from the Alabama River in southwestern Alabama to Smith County, Texas, longitude 95½°, and northward nearly to latitude 33°. Its favored habitat is a damp hollow in pine woods, where the soil is a blackish peaty sand. The soil reaction has been measured at five localities, and found to be mostly high mediacid, active acidity 400, but one locality in westernmost Alabama showed it to be superacid, active acidity 1250. It is to be classed as preferring high mediacid soils.

Hepburn and Jones[3] found the reaction of the pitcher-liquor of this species at Biloxi, Mississippi, to range from active alkalinity 3 to active acidity 10, a composite sample from 40 open pitchers being neutral. My tests at various localities gave similar results; the liquor in two unopened leaves was neutral and low minimacid (active acidity 2), respectively, while in a number of mature ones the highest acidity noted was 10 and the most frequent about 5. Quite unlike the related *S. flava*, then, this pitcherplant secretes essentially neutral material into its pitchers.

Sarracenia jonesii Wherry, sp. nov. MOUNTAIN PITCHERPLANT

In the course of field work in the Blue Ridge of North Carolina, in the summer of 1920, pitcherplants with leaves resembling those of *S. sledgei* were observed to be present in occasional boggy meadows, but were passed over as probably representing an upland form of *S. flava*. In late May, 1927, however, Harry W. Trudell and the writer visited one of their localities, a boggy stream-valley south of Flat Rock Station, in Henderson County, and found this plant in bloom. Much to our surprise the petals proved to be not yellow nor cream-colored at all, but dark red. It could not be *S. rubra*, however, for its leaves were taller, more expanded upward, and provided with larger hoods having more distinctly reflexed margins; the scapes did not markedly exceed the leaves; and the petals and capsules were twice as large as in that species.

On mentioning this to Frank M. Jones, the entomologist of Wilmington, Delaware, who has made such interesting studies of the relations of insects to pitcherplants, and who collaborated with Dr. Hepburn in the monograph on the biochemistry of these plants already referred to, he told me of having observed the same puzzling species in Western Florida. His specimens proved to have the characters of the North Carolina mountain plant; and on looking through the *Sarracenias* in the U. S. National Herbarium it was found that the same thing had been collected at a number of places. When only leaves were represented it had been labelled or annotated *S. catesbaei* or *S. flava*, and when well preserved flowers were included, *S. rubra* (sometimes marked as an anomalous form). Being distinct, however, from *S. rubra* in similar respects to those which led Professor Macfarlane to segregate *S. sledgei* from *S. flava*, it may well be assigned independent status, and I take pleasure in dedicating it to Mr. Jones, with the following characterization:

[3] Trans. Wagner Free Inst. Sci. 11: 71. 1927.

Principal leaves erect, distinctly expanded upward, reaching a height of 75 cm. or possibly more, green with rather inconspicuous red veinings; hood ovate, curving high over the orifice, its sides distinctly but not strongly reflexed. Scapes up to 50 cm. tall; flowers delicately sweet-scented; petals dark red (Ridgway's ox-blood red, 1k, to almost maroon, 3m), up to 3 cm. wide and to 5 cm. long; capsule about 15 mm. in diameter.

Type locality, moist meadow 1.5 mile (2.5 km.) south of Flat Rock Station, Henderson County, North Carolina; type specimen collected by E. T. Wherry, May 13, 1929, deposited in the U. S. National Herbarium, No. 1,438,266. Other collections regarded as representing the same species are:

NORTH CAROLINA: Hendersonville, June, 1881, *Canby;* Muddy Creek, Henderson County, Aug. 21, 1881, *J. Donnell Smith;* Biltmore Estate, 1895, *Boynton;* Baltimore, May 24, 1897, *Biltmore Herbarium* 3374a.

FLORIDA: Walton Co., *Curtiss* 107; De Funiak Springs, April 30, 1898, *Curtiss* 6387.

ALABAMA: Mobile, April 14, 1892, *Mohr;* Fowl River, April 23, 1893, *Mohr.* Jasmine, April 28, 1921, *Harper* 172.

MISSISSIPPI: Waynesboro, August 8, 1896, *Pollard* 1231.

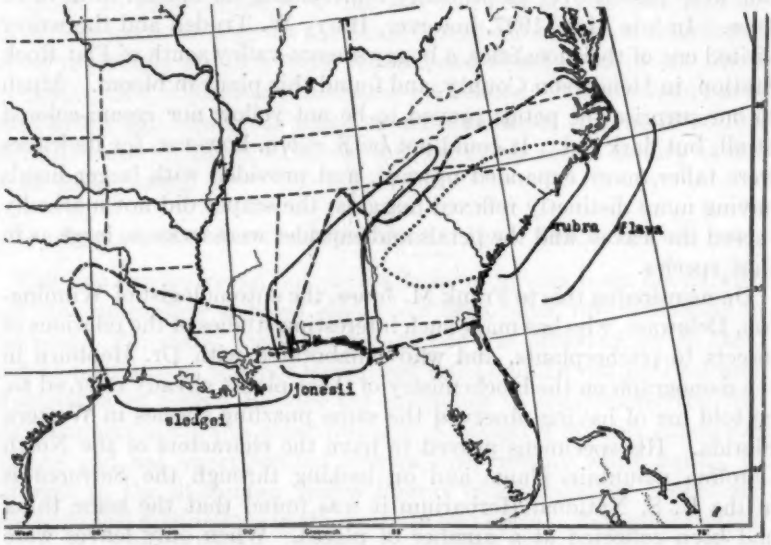
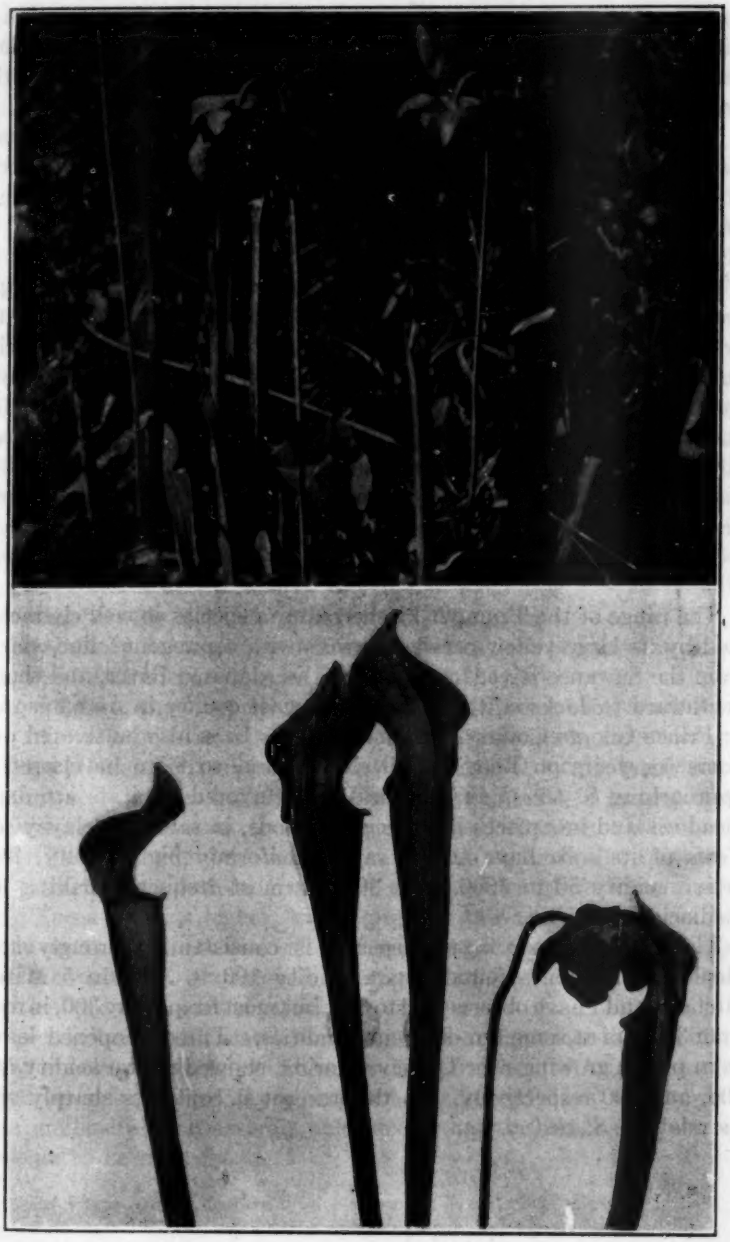


FIG. 1.—Distribution of *Sarracenia jonesii* and related species

The range of this species, then, so far as known, is from Walton Co., Florida to easternmost Mississippi and to Buncombe Co., North Carolina. In the latter region it reaches an altitude of at least 2150 feet (650 meters), high enough for winter temperatures far below freezing, and is thus the hardiest species next to *S. purpurea.* In Figure 1 this range is shown in comparison with those of related



species, all boundaries being approximations, subject to correction as future collecting brings new localities to light. *S. jonesii* is here termed Mountain Pitcherplant because of being the only one of this group of species which pushes far up into the mountains.

The soils at the type locality vary rather widely in reaction, from active acidity 5 to 500, but this plant appears to thrive best at about 50, so it is to be classed as of subacid soil preference. The small amount of liquid in eight pitchers, part of them unopened, showed an active acidity of 30 to 100.

On page 387 are shown two views of *Sarracenia jonesii*, the upper having been taken at the type locality May 13, 1929, the lower in the greenhouse of the U. S. Department of Agriculture, where it is being cultivated in acid soils, along with the other members of the genus, by Dr. Frederick V. Coville. The characters which serve to differentiate it from *S. rubra*, marked expansion of leaves upwards, relatively large hood with somewhat reflexed margins, and large flowers on scapes not markedly exceeding the leaves at blooming time, are well brought out.

S. FLAVA L. TRUMPET PITCHERPLANT

The range of the Trumpet Pitcherplant, a species so well characterized by its large yellow-petalled flowers with a pungent feline odor, is from the Suwanee River in Florida to the Alabama River, and thence northward to Jackson, the northeasternmost county in Alabama, and to Prince George County, Virginia. It has been also cultivated outdoors for years on Long Island, New York, so is to be classed as approaching *S. jonesii* in hardiness. Its favored habitats are damp meadows and low places in open pine woods, in sandy or clayey soil. Tests of its soils have shown rather uniformly high acidity, from active acidity 50 to 1000, with 300 the most frequent, making it a mediacid soil plant.

The pitcher-liquor in this species is consistently strongly acid. Hepburn and Jones found active acidity 100 to 3000 in 5 mature pitchers, and I have observed 30 to 500, but most frequently 300, in more than 30 tests at some ten different localities. Three unopened leaves from plants growing near Quincy, Florida, showed active acidity 500, 600, and 800 respectively. In this respect it contrasts sharply with its relative, *S. sledgei*.

The Catesby Pitcherplant, a hybrid of *S. flava* with *S. purpurea* (*S. catesbaei* Ell.) was studied in a swamp west of Quincy, the soil proving to be low mediacid, active acidity 200, and the liquor in two mature pitchers high minimacid, acidity 5 and 6. In these respects the hybrid resembled the second named parent more than the first.

S. DRUMMONDII Croom. DRUMMOND PITCHERPLANT

This largest and showiest of the *Sarracenias* is well distinguished from all others by the mottling and veining of the upper parts of the leaves with white, green, and red. There has been some misunderstanding about its range, for in Miss Lounsberry's book on southern plants,[6] it is stated to be especially common between Aiken, South Carolina, and Richmond County, North Carolina. Actually, only *S. rubra* and *flava* are common there, and the easternmost authenticated record of *S. drummondii* is in Sumter County, Georgia, longitude 84°. In Florida it occurs only toward the western end, although like several other species it extends into southern Mississippi. Reaction measurements have been made on this species at two localities, in the general vicinity of Milton, Santa Rosa County, Florida. The soil proved to have active acidity 150 to 400, averaging 250, so that like the next preceding it is a mediacid soil plant.

Hepburn and Jones recorded measurements on the liquor in 5 open pitchers of this species near Freeport, in the same part of Florida, three of them showing active acidity 3, the other two active alkalinity 3. My tests in a swamp east of Milton showed the liquid in two unopened pitchers to be alkaline, active alkalinity 10 and 30, respectively, the latter being the highest alkalinity as yet observed in any of the species. A number of open pitchers ranged from neutral to active acidity 30, although the majority were but minimacid. In spite of its growth in acid soils, then, this plant evidently secretes alkaline substances into its leaves, which prevent the acidity rising as high as in most of the others. It is interesting to note that *S. sledgei*, which overlaps *S. drummondii* in range from the west, is also characterized by circumneutral pitcher-liquor.

In conclusion, the reactions of the soils and pitcher-liquors in the eight species of pitcher-plants may be tabulated to bring out their relations graphically. A light-face letter X indicates that a given reaction has been observed, a bold-face **X** that the designated reaction appears to be most frequent.

[6] Alice Lounsberry. *Southern Wild Flowers and Trees*. 206. 1901.

TABLE 1. SOIL REACTIONS OF THE SARRACENIAS

Species	superacid	mediacid	subacid	minim-acid	neutral	minim-alk.	subalk.
psittacina	—	X	—	—	—	—	—
purpurea	X	X	X	X	X	X	—
minor	—	X	X	—	—	—	—
rubra	—	X	—	—	—	—	—
sledgei	X	X	—	—	—	—	—
jonesii	—	X	X	X	—	—	—
flava	X	X	X	—	—	—	—
drummondii	—	X	—	—	—	—	—

TABLE 2. PITCHER-LIQUOR REACTIONS OF THE SARRACENIAS

Species	superacid	mediacid	subacid	minim-acid	neutral	minim-alk.	subalk.
psittacina	—	X	—	—	—	—	—
purpurea	X	X	X	X	X	X	X
minor	X	X	—	—	—	—	—
rubra	—	X	—	—	—	—	—
sledgei	—	—	X	X	X	X	—
jonesii	—	X	X	—	—	—	—
flava	X	X	X	—	—	—	—
drummondii	—	—	X	X	X	X	X

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

408TH MEETING

The 408th regular meeting of the Entomological Society of Washington was held at 8 p.m., Thursday, February 7, 1929, in Room 43 of the New Building of the U. S. National Museum. Mr. J. E. GRAF, President, presided. There were present 30 members and 21 visitors. Doctor HOWARD expressed his regret at the small attendance reported for the previous meeting and urged that there be no repetition of such lapses at future important meetings in which special tribute would be rendered to visitors.

The Executive Committee recommended for membership the following new candidate who was duly elected on vote of the Society: Mrs. J. B. REESIDE, Jr., of Hyattsville, Maryland.

Doctor HOWARD referred to the recent death of Dr. H. G. DYAR and read the following resolutions which by vote of the Society were spread upon its minutes:

The Entomological Society of Washington records with deep regret the death of Dr. HARRISON G. DYAR on January 21, 1929. Doctor DYAR had worked in the U. S. National Museum for thirty-one years. He had been Custodian of the Lepidoptera, and at one time Assistant Curator of the Division of Insects; also for a time editor of the Proceedings of this Society.

Among his many papers, he published a classification of Lepidopterous larvae (1894), a great list (or catalog) of the North American Lepidoptera (1902) and very many other papers concerning Lepidoptera. Becoming interested in the Culicidae in 1903, he was coauthor of the four-volume Monograph of the Mosquitoes of North and Central America and the West Indies (1917–18), and shortly before his death completed and published a large volume entitled "The Mosquitoes of the Americas." He also founded and edited the monthly journal known as *Insecutor Inscitiae Menstruus*, of which fourteen volumes were published. He was a tireless worker, and his name will always be prominent in the annals of American entomology.

The first paper on the regular program was the Annual Address of the retiring president, Mr. S. A. ROHWER, and was entitled "Economic Aspects of Taxonomic Entomology." This paper will be published in full in an early number of the Proceedings of the Society. Comment on this paper was made by GRAF, HOWARD, BAKER, ALDRICH, GAHAN, CORY, BLISS, and CUSHMAN.

The next paper on the program was presented by Mr. W. H. WHITE, and was entitled "The A. B. C. of truck crop entomology." The principal object in presenting this paper was to bring to the attention of the Society something of the nature of the work which is being carried on with the Office of Visual Education of the Extension Service of the Department. A considerable number of lantern slides, showing the various manners in which insects attack vegetables together with insecticide appliance, were shown and explained. Comment on this paper was made by BAKER and WEBB.

Brief remarks were made on invitation by Dr. C. I. BLISS, of the Bureau of Entomology, regarding the recently established U. S. Entomological Laboratory in Mexico City in coöperation with the Mexican Government for the study of the Mexican fruit fly. Emphasis is being placed on investigation of the various climatic factors, including atmospheric pressure at varying altitudes. Data also is being secured on soil conditions, host plants, and other like subdivisions of the investigation, in the hope that the information obtained in Mexico may be useful in predicting the possibilities of survival of the fly should it appear in citrus regions of the United States and for control work in that contingency.

Comment on the remarks of Doctor BLISS were made by BAKER, HOWARD, and GRAF.

409TH MEETING

The 409th regular meeting was held at 8 p.m., Thursday, March 7, in Room 43 of the New Building of the U. S. National Museum. Mr. J. E. GRAF, President, presided. There were present 27 members and 24 visitors.

The Corresponding Secretary-Treasurer, Mr. ROHWER, reported briefly on a meeting of the Executive Committee of the Society on February 27th at which consideration was given to a suggested policy of participation in formulation of programs with the Washington Academy of Sciences, and in which favorable action was taken in connection with exchanges of our Proceedings with various foreign organizations, and in which certain other minor matters were given attention.

The Executive Committee recommended for membership the following new candidate who was duly elected on vote of the Society: Miss MABEL COLCORD, Librarian of the U. S. Bureau of Entomology, Washington, D. C.

The first paper on the regular program was by Doctor WILLIAM SCHAUS and was entitled "Collecting Butterflies in the American Tropics."

In his talk to the members of the Society, Doctor SCHAUS took them in spirit from Vera Cruz, Mexico, to Jalapa, then to the table-lands by way of Perote and around the Volcano of Orizaba down to the temperate zone at Cordoba and across country by the way of Huatusco back to Jalapa; subsequently by Las Vigas in a northeasterly direction to Tuxpan, returning by Misantla to his headquarters, relating many experiences and giving descriptions of the country. Subsequently trips were made to the Volcano Popocatepetl and on the west coast to Cuernavaca and Uruapan, also to the Isthmus of Tehuantepec. In Guatemala, headquarters were made at Cayuga and repeated excursions were made along the railway, also to the city, and on the Pacific slope from Escuintla to Mazatenango and Retalhuleu with side trips to the slopes of the Volcano of Santa Maria, also on the eastern side of the country to numerous points in Verapaz. In Costa Rica the country was well covered by repeated trips on both the Caribbean and Pacific sides, and this at all seasons of the year and during a period of three years. Some time was spent on the Volcanos of Poas and Turrialba, this at different seasons of the year, the collecting depending upon the amount of rainfall and sunshine. For night work nothing was quite equal to an electric arc light. (Author's abstract.)

This paper was discussed by GRAF, EWING, CLARK, and BAKER.

One of our visitors, Doctor D. M. DELONG, Ohio State University, Columbus, Ohio, on invitation, addressed the Society briefly on some experimental work performed by him the past summer on the possible uses of Bordeaux mixture as an insecticide, with special reference to leafhopper control. Some details were presented on the different combinations and variations, and on the equipment employed, and a brief summary was given of general results obtained.

Mr. G. G. BECKER, Plant Quarantine and Control Administration, on invitation also greeted the Society and expressed pleasure at being with us.

Mr. ROHWER presented a brief note on the birch leaf-miner, described by MacGillivary in 1909 as *Phlebatrophia mathesoni*. This note will be published in full in an early number of the Proceedings of our Society.

Mr. BISHOPP reported that an appropriation of $12,000 in the recently approved Deficiency Bill had been secured for investigation of certain species of buzz gnats in the genus *Hippelates* in portions of southern California. He discussed injury by this pest and cited instances of its serious character. These remarks were discussed by BAKER.

410TH MEETING

The 410th regular meeting was held at 8 P.M. Thursday, April 4, in Room 43 of the new building of the U. S. National Museum. Mr. J. E. GRAF, President, presided. There were present 24 members and 8 visitors.

The Executive Committee recommended for membership the following new candidates who were duly elected on vote of the Society: CHARLES H. MARTIN, H. S. PETERS, F. M. WADLEY, G. G. BECKER, O. E. GAHM, J. E. WALTER.

The Corresponding Secretary-Treasurer, Mr. ROHWER, reported that Dr. T. E. SNYDER, due to prolonged absence from the city, had resigned from the Program Committee, and that Dr. HAROLD MORRISON had been appointed to take his place, the other members of the Committee now being Dr. C. A. WEIGLE, and Dr. N. E. MCINDOO.

The first paper on the regular program was presented by Dr. F. M. WADLEY, and was entitled "On the nature of injury of *Toxoptera graminum* to its host plants."

"*Toxoptera graminum* is more injurious in proportion to its numbers than other common grain aphids. Its feeding causes pale spots with red centers on the leaves of its food plants. Injury invariably followed feeding and was proportional to the amount of feeding. Paleness was apparently caused by destruction of chlorophyll, while the red spots were due to reddening of the leaf cell nuclei. A water extract of *Toxoptera* slowly decolorized a solution of refined chlorophyll. On heating, the extract lost this power. It seems likely that an enzyme is the cause of the destruction of chlorophyll." (Author's abstract.)

This paper was discussed by WALTON, BAKER, GAHAN, MORRISON, CORY, SNODGRASS, WOOD, and GRAF.

The second paper on the program was entitled "Host Relationships of the North American Chigger, *Trombicula irritans* (Riley)," by Dr. H. E. EWING of the Bureau of Entomology.

"Recent surveys made in some of the Middle Atlantic States of the possible hosts of *Trombicula irritans* (Riley) showed that it parasitized certain species of four classes of Vertebrata: Amphibia, Reptilia, Aves and Mammalia. Among the resistant vertebrates (non hosts) were pit-vipers, some turtles, insectivors and most rodents. Susceptible hosts are of two kinds: Those that are susceptible at all active stages of their life history and those that are susceptible only at certain stages, as is the case of Fowler's toad. This toad (*Bufo fowleri*) is infested only when the individuals are very young, yet tailless. Many vertebrates occurring in chigger-infested areas, during the chigger season, are not attacked because their habits keep them in situations not reached by the active larvae. Water snakes, tree-frequenting birds and mammals living in overflow land are in this category." (Author's abstract.)

Dr. EWING's paper was discussed by WALTON, BAKER, GAHAN, MORRISON, CORY, SNODGRASS, WOOD, and GRAF.

Dr. P. W. CLAASSEN, of Cornell University, Ithaca, N.Y., on invitation made a few remarks more or less humorous in character relative to the subject matter of the previous speakers, and discussing some of his recent work in the vicinity of Ithaca on immature stages of Plecoptera. These observations were discussed briefly by ROHWER.

411TH MEETING

The 411th regular meeting was held at 8 P. M., Thursday, May 2nd, in Room 43 of the new building of the U. S. National Museum. Mr. J. E. GRAF, president, presided. There were present 46 members and 45 visitors.

There were no preliminary business matters for discussion, so attention was given at once to the main feature of the evening,—this consisting of an informal address by Dr. C. L. MARLATT on the Mediterranean fruit fly situation in Florida. In this address, Doctor MARLATT reviewed very briefly the status of the insect as a pest in other countries and the various official measures taken to intercept and keep it out of this country. He then discussed the recent finding of the pest in Florida and the events immediately following this, including his own recent trip to the Orlando and Gainesville territory and his personal observations on the injury and spread of the pest. A summary also was given of the organization of the cooperative exterminative work now being performed by Federal and State authorities, and a review was given of the events connected with the appropriation of Federal funds and assignment of State and other funds for the work. Maps of the area of

infestation and a number of slides were shown, the latter dealing with the injury, life history, and control of the pest.

Dr. MARLATT'S paper was discussed by CLARK, MCINDOO, BACK, BECKER, PERRINE, and POOS.

Mr. ROHWER referred to the recent recurrence of the Mexican fruit worm in the Lower Rio Grande Valley of Texas, stating that it had been found in a few fruits at three different places within the Valley. Because of the delay in the ripening of grapefruit due to the unfavorable rainy season of the autumn, the shipping season had been extended one month and the fruit allowed to remain on the trees until the 30th of March. This extension of the shipping season left fruit susceptible of infestation by the fly on the trees a longer period, and may have been in part responsible for the recurrence of the insect. This emphasizes the continuing danger of a reinfestation and may even indicate that the insect has not been completely eradicated from the Valley. In any event, it emphasizes the need of continual vigilance in the enforcement of the quarantine regulations as originally planned.

J. S. WADE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Dr. RAY S. BASSLER, of the U. S. National Museum, has returned from Prague, Czechoslovakia, where he has spent some time making casts of types of species of fossils described in Barrande's Système Silurien du Centre de la Bohème.

Dr. LYMAN F. KEBLER has resigned from the Office of Collaborative Investigations of the Food, Drug, and Insecticide Administration, U. S. Department of Agriculture, to become Medical Director of the Doctors' Essential Food Company and the Bowman Hotels Corporation, with offices in Washington, D. C.

Obituary

PETER A. YODER, Associate Technologist in Sugar-cane Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, and a member of the ACADEMY, died on July 20 in Washington, D. C. He was born in Shipshewana, Indiana, August 21, 1867, and studied at Indiana University, receiving the degrees of A.B. in 1894 and A.M. in 1896. He took post-graduate work at the University of Chicago for a year, and then went to Göttingen, Germany, where he received the degree of Ph.D. in 1901. He taught in various high schools and colleges for several years, was Director of the Utah Experiment Station from 1905 to 1907, and research chemist at the Louisiana Sugar Experiment Station, 1908 to 1910. He entered the Bureau of Chemistry of the U. S. Department of Agriculture in 1910, and three years later was transferred to the position in the Bureau of Plant Industry which he held up to the time of his death. He was the author of a number of papers on various phases of organic chemistry, agronomy, and sugar technology, and in recent years was stationed at Cairo, Georgia, in charge of the Department of Agriculture's Sugar Plant Field Station, where he was engaged in investigating the production of cane sirup.